RT042068, RT042084) and four open water sites (RO036043, RO036052, RO036058, RO046081) had salinity ranges ≥ 20 ppt, which may represent stressful conditions to many species. Until additional data are available, no criteria have been established by SCECAP to identify stressful conditions using salinity. The sites having these salinity ranges likely reflect the effects of major rainfall events that occurred just before or during our deployment of the datasondes.

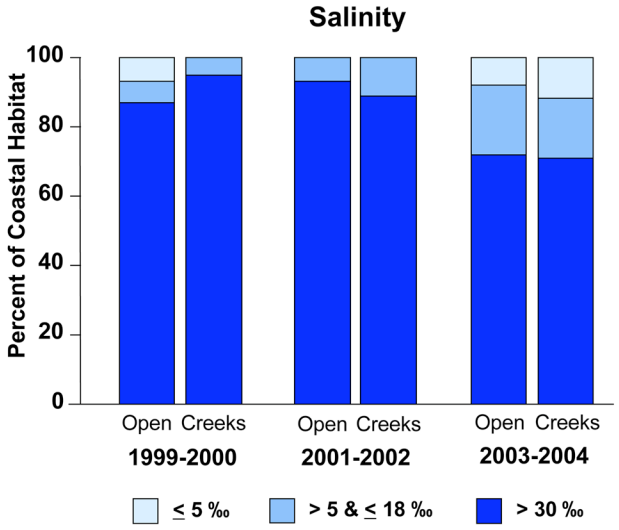

Figure 3.2.1. Comparison of the percent of the state's coastal habitat that represented various salinity ranges during the three survey periods conducted from 1999-2004.

The average difference between surface and bottom salinity measurements taken during the primary station visit was 0.3 ppt in tidal creeks and 0.9 ppt in open water areas. Only one tidal creek site had a difference > 5 ppt, and surface to bottom differences at the majority of creek sites were < 1 ppt (data online). This was also the case for open water stations, with only four stations having > 5 ppt variation in salinity.

Dissolved Oxygen

Low dissolved oxygen (DO) conditions can limit the distribution or survival of most estuarine biota, especially if these conditions persist for extended time periods (see Diaz and Rosenberg, 1995; USEPA, 2001 for reviews). Dissolved oxygen criteria established by the SCDHEC for "Shellfish Harvesting Waters" (SFH) and Class SA saltwaters are a daily average not less than 5.0 mg/L with no values less than 4.0 mg/L (SCDHEC, 2004). Class SB waters should have no values less than 4.0 mg/L. The SCECAP program was designed to sample only during a summer index period when DO levels are expected to be at their lowest. As a result, it was expected that DO measurements collected in this program probably represent short-term worst-case conditions that may not reflect conditions during other seasons or longer time-averaging periods. Although that expected pattern was not reflected in our comparison of summer only versus 12-month measurements of dissolved oxygen (Box 3.2.2), SCDHEC requires year-round monthly measurements for their regulatory purposes. Therefore SCECAP data should be used only to identify coastal habitats where DO levels may be limiting. Based on the state water quality standards, mean or instantaneous DO concentrations > 4 mg/L are considered to be good for summer time periods, values < 4 mg/L and ≥ 3 mg/L are considered to be fair (i.e., contravenes one portion of the state standards), and average or instantaneous measures < 3 mg/L are considered to be poor and potentially stressful to many invertebrate and fish species.

The average bottom DO concentration at the open water stations during the 2003-2004 survey was 5.2 mg/L, with approximately 90% of the state's open water habitat having an average DO > 4.0 mg/L based on the 25-hr instrument deployments (Figure 3.2.2; data online). These conditions were very comparable to DO conditions observed in the previous survey period (Van Dolah *et al*., 2004a). Only two open water sites (representing approximately 3% of the state's open water habitat) had an average DO < 3.0 mg/L (RO036043, RO046076). These sites were in the South Edisto River and the North Santee River, respectively (Appendix 2). The latter site also had an instantaneous bottom DO of 2.3 mg/L, with a surface water DO concentration of 3.1 mg/L.

The average bottom DO concentration observed at tidal creek sites was 4.8 mg/L, with 85% of this habitat having an average DO value > 4.0 mg/L. The average DO value observed among the tidal creek sites was significantly lower than the average DO observed among the open water sites ($p = 0.003$), but this difference is not likely to be biologically meaningful since the average difference was < 0.5 mg/L and both

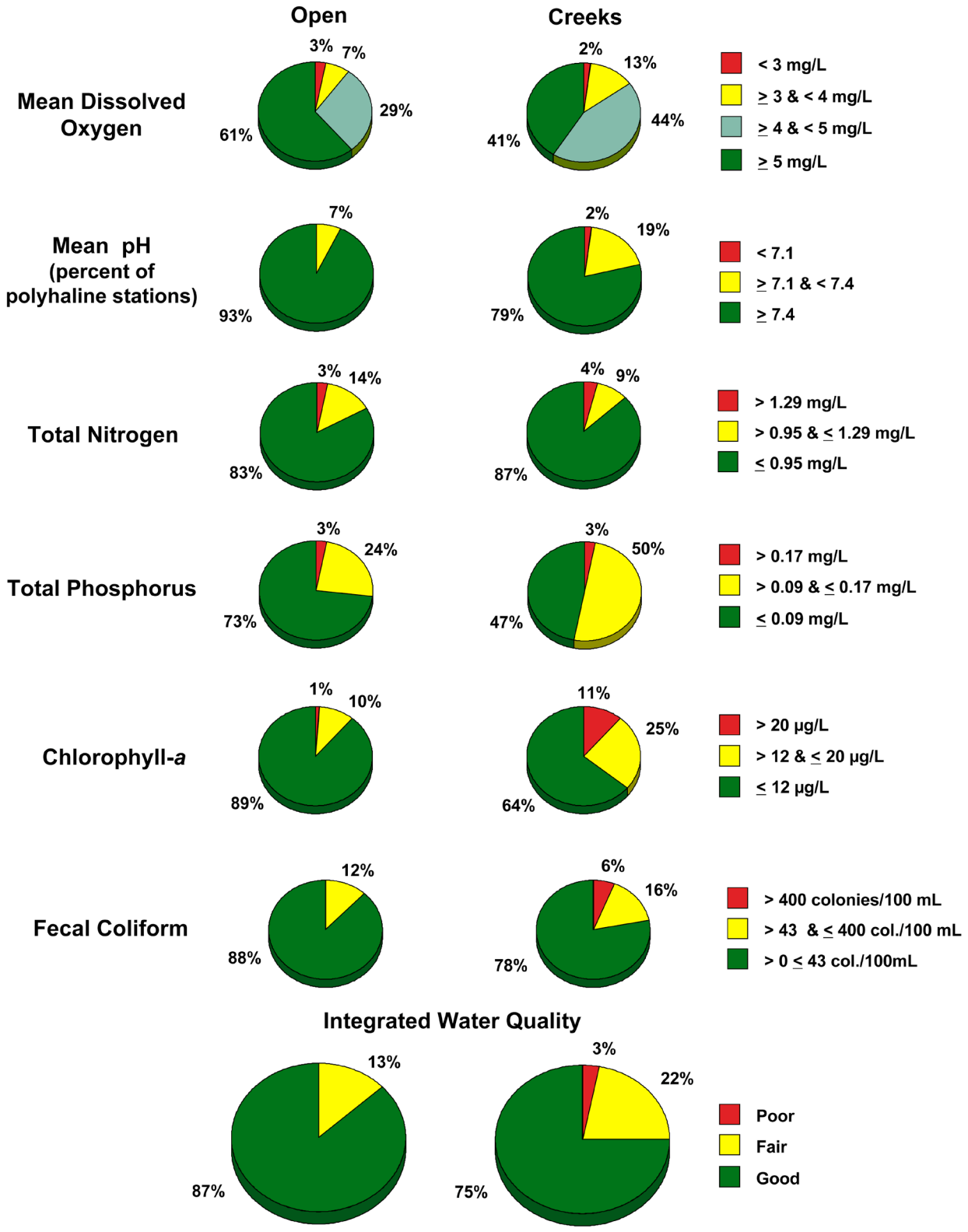

Figure 3.2.2. Comparison of the percent of the state's coastal habitat that represented various water quality conditions for selected water quality parameters and for the integrated water quality index.

averages were > 4.0 mg/L. Approximately 2% of the state's tidal creek habitat had average DO levels < 3.0 mg/L and 13% of this habitat had DO levels between 3.0 and 4.0 mg/L, which is similar to the previous survey period (Van Dolah *et al.*, 2004a) Tidal creek sites often had a greater range in DO concentrations than the open water sites (data online).

Although numeric state DO standards apply to all waters, the SCECAP data continue to suggest that lower DO concentrations in tidal creeks may be normal during the summer months compared to larger water bodies. When making regulatory decisions in such situations, the practice of considering natural background conditions seems appropriate. Even so, creek sites with mean DO levels < 3.0 mg/L may not fully support biological assemblages, especially during periods when DO levels are less than 2.0 mg/L (hypoxic conditions). Hypoxic conditions are known to be limiting to many estuarine and marine biota (Gibson *et al*., 2000).

As noted in the previous two survey periods (Van Dolah *et al*., 2002a, 2004a), the instantaneous measures of bottom DO were, on average, lower than the mean DO values obtained from the 25-hr deployment of water quality datasondes among both the open water (0.7 mg/L difference) and tidal creek sites (1.1 mg/L difference, data online). In contrast to the previous surveys, these differences were statistically significant ($p < 0.002$) during the current survey. The instantaneous bottom DO measure at each site was only weakly correlated to the average bottom DO obtained from the 25-hr instrument deployment ($r^2 = 0.22$), which was also the case in the previous surveys. While instantaneous measures of DO and other water quality parameters are the only feasible approach for SCDHEC to use for the year-round assessment of coastal water quality, mean DO conditions are best measured over a longer period that includes both day and night measures during all tidal stages.

Finally, it should be noted that SCDHEC uses surface water quality measures for regulatory and reporting purposes. The mean differences between surface and bottom readings during the primary site visit was only 0.2 mg/L for both habitat types and only two open water sites had a difference in DO readings of more than 1.0 mg/L (data online). Thus, the surface readings should be reasonably protective of bottom water habitats for South Carolina waters.

pH

Measures of pH provide another indicator of water quality in estuarine habitats that has often been ignored by other sampling programs at the state or national level. Measures of pH are based on a logarithmic scale, so even small changes in the value can result in significant stress to estuarine organisms (Bamber, 1987, 1990; Ringwood and Keppler, 2002). Unusually low or high pH values may indicate the presence of pollutants (e.g. release of acids or caustic materials) or high concentrations of carbon dioxide (Gibson *et al.*, 2000). Because salinity and alkalinity affect the pH of estuarine waters, SCDHEC has established water quality standards that account for these effects. The pH in Class SA and SB tidal saltwater areas should not vary more than one-half of a pH unit above or below effluent-free waters in the same geologic area having a similar salinity, alkalinity and temperature, and values should never be lower than 6.5 or higher than 8.5. Shellfish Harvesting waters (SFH) shouldn't deviate more than 0.3 units from effluent-free waters. Based on these criteria, pH criteria were established for SCECAP assessments using data collected from pristine environments sampled in 1999-2000 (e.g. Cape Romain National Wildlife Refuge, ACE Basin and North Inlet-Winyah National Estuarine Research Reserves, SFH class saltwaters) to identify pH levels that were considered to represent good, fair, and poor conditions for polyhaline waters (> 18 ppt; Van Dolah *et al*., 2002a). For polyhaline waters, pH levels ≥ 7.4 are considered to be good. Values below 7.4 and above 7.1 pH units are considered to be fair since they represent the lower 10^{th} percentile of all pH records observed for polyhaline waters during the 1999-2000 survey. Values below 7.1 pH units are below the 0.5 pH unit variation allowed for effluent-free waters and are considered to be poor pH conditions. Criteria are still not established for lower salinity waters since the extreme drought conditions experienced from 1999-2002 limited the number of sites with salinities < 18 ppt. The return of normal rainfall conditions should allow us to develop criteria for oligohaline and mesohaline waters following the 2005-2006 survey now in progress.